

5617
Spring 2020
03/16/2020

Name: _____
Midterm
Time Limit: 120 minutes

- **Print** your name.
- Open-book policy: You may use the text book, printed class notes and/or any printed notes and handwritten study guides you have created. You may use a calculator. You may not use ebook or slides, or any search-able documents.

Problem	Points	Score
1	25	
2	50	
3	4	
4	3	
5	4	
6	4	
7	4	
8	6	
Total:	100	

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1. True or False

- (1.1) (1 point) The golden rule in traffic engineering is: *Design your system so that the traffic intensity is no greater than 1.* (Traffic intensity is the ratio La/R where Ra is the traffic arrival rate, R is the transmission rate.)
A. true B. false
- (1.2) (1 point) For an application to enjoy reliable data transfer, it must run over TCP.
A. true B. false
- (1.3) (1 point) Packet-switching is not always “better” than circuit-switching, the (design of the) later is simpler and offers guarantees such as bandwidth.
A. true B. false
- (1.4) (1 point) End systems, packet switches, and other pieces of the Internet *all* run protocols that control the sending and receiving of information within the Internet.
A. true B. false
- (1.5) (1 point) The network core is the mesh of packet switches and links that interconnects the Internet’s edge.
A. true B. false
- (1.6) (1 point) Traffic intensity (La/R) is the ratio of traffic arrival rate (La) and transmission rate (R). The golden rule of traffic engineering is: Design your system so that the traffic intensity is no greater than 1.
A. true B. false
- (1.7) (1 point) If packets arrive periodically (not bursts), then every packet will arrive at an empty queue without incurring any queueing delay.
A. true B. false
- (1.8) (1 point) In store-and-forward transmission, a switch must buffer a packet’s bits because the packet switch must receive the entire packet before it can begin to send the first bit of the packet.
A. true B. false
- (1.9) (1 point) Google, by creating its private network, bypasses the upper tiers of the Internet, reduces its payment, and achieves greater control of how its services are delivered.
A. true B. false
- (1.10) (1 point) In the context of any given communication session between a pair of processes, we will label one process as the client and the other process as the server only if in a server-client architecture.
A. true B. false
- (1.11) (1 point) TCP congestion control and flow control take similar actions that treating different symptoms.
A. true B. false
- (1.12) (1 point) We studied a pipelined protocol called GBN (Go-Back-N) that achieves reliable data transfer. TCP is simply a realization of the GBN protocol.
A. true B. false
- (1.13) (1 point) When multiple applications running over TCP share a common bottleneck, TCP congestion control will ensure fair share among those applications.
A. true B. false

- (1.14) (1 point) One of the most compelling features of P2P architectures is their self-scalability.
A. true B. false
- (1.15) (1 point) The Internet architecture operates over a wide variety of networks
A. true B. false
- (1.16) (1 point) End points retransmission of lost packets works well only if the retransmission rate is low.
A. true B. false
- (1.17) (1 point) The end to end argument moves network functionalities upwards in the layered network architecture, closer to the applications that use the function.
A. true B. false
- (1.18) (1 point) TCP congestion avoidance strategy can be summarized by additive increase and multiplicative decrease
A. true B. false
- (1.19) (1 point) A layered architecture enables a networked system to remain unchanged when a layer's implementation is changed.
A. true B. false
- (1.20) (1 point) DNS is a core network function that is implemented at application layer via the client-server paradigm.
A. True B. False
- (1.21) (1 point) The transport-layer provides the end to end logical communication between two hosts.
A. True B. False
- (1.22) (1 point) Transport layer congestion control is not so much a service provided to the invoking application as it is a service for the Internet as a whole.
A. True B. False
- (1.23) (1 point) TCP fast retransmit addresses the problem of relatively long time-out period
A. True B. False
- (1.24) (1 point) During TCP slow start, the sender's initial rate is slow but ramps up exponentially fast.
A. True B. False
- (1.25) (1 point) Two applications can achieve fair share of a bottleneck network link as long as they are both running over TCP.
A. True B. False

2. Multiple choice questions

- (2.1) (2 points) A TCP sender can detect a “loss event” by
- A. timeout
 - B. duplicate ACKs
 - C. ACK with ECE (explicit congestion notification echo) bit
 - D. all of the above
- (2.2) (2 points) In TCP, define `ccwnd` to be the congestion window size, `rcwnd` to be the receive window size, the amount of unacknowledged data can not exceed
- A. `rcwnd`
 - B. `ccwnd`
 - C. `min{ccwnd,rcwnd}`
 - D. `max{ccwnd,rcwnd}`
- (2.3) (2 points) TCP connection is a logical one, consisting of _____ in the two communicating hosts.
- A. buffers
 - B. variables
 - C. socket connection to a process
 - D. all of the above
- (2.4) (2 points) Which of the following mechanism(s) address(es) packet loss?
- A. sequence number
 - B. retransmission
 - C. timer
 - D. all of the above
- (2.5) (2 points) In Go-Back-N (GBN) protocol, define `N` to be the maximum allowable number of packets that can be transmitted without waiting for an acknowledgment, `base` to be the sequence number of the oldest unacknowledged packet, and `nextseqnum` to be the smallest unused sequence number. The sequence number of in-flight packets falls into:
- A. `[0,base-1]`
 - B. `[base,nextseqnum-1]`
 - C. `[nextseqnum,base+N-1]`
 - D. `>base+N`
- (2.6) (2 points) Reliable data transfer can occur at
- A. transport-layer
 - B. link layer
 - C. application layer
 - D. all of the above
- (2.7) (2 points) Reliable data transfer is realized through
- A. error detection
 - B. receiver feedback
 - C. retransmission
 - D. all of the above
- (2.8) (2 points) A TCP socket is identified by a four-tuple: (source IP address, source port number, destination IP address, destination port number). Consider two hosts A and C, and one server B. Hosts A and C and server B each have their own unique IP addresses — A, C, and B, respectively. Host A assigns source port number 2614 to its one single

HTTP connection to B. Host C assigns two different source port numbers — 2614 and 3126 — to its two HTTP connections to B. Also suppose The port number assigned for HTTP web server is 80. What is the four-tuple that identifies a TCP socket connecting C and B?

- A. only (C, 2614, B, 80)
 - B. only (C, 3126, B, 80)
 - C. either (C, 3126, B, 80) or (C, 2614, B, 80)
 - D. none of the above
- (2.9) (2 points) Which of the following devices can *not* run an application-layer protocol?
- A. laptop
 - B. smartphone
 - C. router
 - D. traffic control system
- (2.10) (2 points) IP does not assume
- A. reliable sequenced data transfer
 - B. differentiated services
 - C. internal knowledge of failures, speed, delay
 - D. all of the above
- (2.11) (2 points) *traceroute* is a program that can run in any Internet host. Given a certain destination host, it probes all the routers along the path to that destination, generating round-trip delays for all those intermediary routers. The round-trip delay to the n th router, however, can be greater than the $n + 1$ th router. This is because the _____ can be varying with time.
- A. transmission delay
 - B. processing delay
 - C. queueing delay
 - D. propagation delay
- (2.12) (2 points) Which of the following protocol(s) define today's Internet architecture?
- A. SMTP, DNS
 - B. TCP, UDP
 - C. routing protocols
 - D. IP
- (2.13) (2 points) In a layered architecture, HTTP need not worry about lost data or the details of how the underlying network recover from loss or reordering of data within the network. HTTP simply relies on _____ for realizing all these requirements.
- A. UDP
 - B. TCP
 - C. IP
 - D. TCP/IP
- (2.14) (2 points) A centralized design of DNS will not scale, because
- A. The server becomes a single point of failure
 - B. Significant delay (during communication) to distant querying clients
 - C. The server will need to handle a high volumn of traffic
 - D. all of the above
- (2.15) (2 points) Consider file distribution in a network of 1 server and N peers: the server owns a file, the task is to get every peer a copy. Suppose the upload rate of the server is u_s , the download and upload rate of i th peer is d_i (The minimum download rate is d_{min}) and u_i . The size of the file is F . In a P2P architecture, the time it takes to upload the file is at least:

- A. \mathbf{F}/\mathbf{u}_s
 - B. $\mathbf{NF}/\mathbf{u}_s + \mathbf{u}_i + \cdots + \mathbf{u}_N$
 - C. $\max\{\mathbf{F}/\mathbf{u}_s, \mathbf{NF}/(\mathbf{u}_s + \mathbf{u}_i + \cdots + \mathbf{u}_N)\}$
 - D. $\max\{\mathbf{F}/\mathbf{u}_s, \mathbf{NF}/(\mathbf{u}_s + \mathbf{u}_i + \cdots + \mathbf{u}_N), \mathbf{F}/\mathbf{d}_{\min}\}$
- (2.16) (2 points) Reliable data transfer
- A. is the first service recognized and implemented with TCP (transmission control protocol)
 - B. had multiple variants
 - C. is a serious source of delay in the network
 - D. all of the above
- (2.17) (2 points) Which layer(s) in the Internet protocol stack does a host process
- A. application layer
 - B. network layer
 - C. transport layer
 - D. all of the above
- (2.18) (2 points) A protocol does *not* define
- A. the specific implementation of a protocol
 - B. the format and the order of messages exchanged
 - C. actions taken on the transmission and/or receipt of a message
 - D. all activity in the Internet that involves two or more communicating entities
- (2.19) (2 points) The mechanisms enabling reliable data transfer do *not* include
- A. socket programming
 - B. timeout
 - C. error detection
 - D. retransmission
- (2.20) (2 points) Which of the following service(s) is (are) provided by UDP?
- A. reliable data transfer
 - B. throughput
 - C. multiplexing and demultiplexing
 - D. none of the above
- (2.21) (2 points) Which information is used by a process running one host to identify a process running on another process?
- A. IP address
 - B. port number
 - C. protocol
 - D. none of the above
- (2.22) (2 points) In reliable data transfer, sequence number is introduced to address
- A. losses in the network
 - B. duplicate packets after retransmission
 - C. detect error
 - D. packet reordering in the network
- (2.23) (2 points) Software-defined networking (SDN) is an emerging paradigm that attempts to
- A. reduce cost and break the vendor-lock
 - B. more disciplined networking practice
 - C. foster innovation
 - D. all of the above
- (2.24) (2 points) The key SDN techniques do not include

- A. Centralized network control
- B. Programmable high-level network abstractions
- C. layered architecture
- D. Decouples network control from traffic processing

(2.25) (2 points) Which of the following(s) apply (applies) to the end to end argument

- A. Keep the network core simple and push the complexity (functionalities) towards to the network edge
- B. The function of concern can be correctly implemented only with the knowledge and help of the application that uses the function
- C. Implementing the questioned function in the network core is often hard and redundant — the application standing at the endpoint will need to implement it anyway
- D. all of the above

3. **Written questions (short answer)** Consider how UDP receiver computes the Internet checksum
- (3.1) (2 points) Suppose you have the following 2 bytes: 01011101 and 01100101. What is the 1s complement of the sum of these 2 bytes?
- (3.2) (2 points) Suppose that the UDP receiver computes the Internet checksum for the received UDP segment and finds that it matches the value carried in the checksum field. Can the receiver be absolutely certain that no bit errors have occurred? Explain.

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4. **Written questions (essay, computational)** Suppose Host A wants to send a large file to Host B. The path from A to B has three links, of rates $R_1 = 1Mbps$, $R_2 = 200kbps$, $R_3 = 500kbps$.
- (4.1) (1 point) Assuming no other traffic in the network, what is the throughput for the file transfer?
- (4.2) (2 points) Suppose the file is 8 million bytes. Dividing the file size by the throughput, roughly how long will it take the file to Host B?

5. **Written questions (essay, computational)** Suppose users share a 10 Mbps link. Also suppose each user transmits continuously at 2 Mbps when transmitting, but each user transmits only 30 percent of the time.
- (5.1) (1 point) When circuit switching is used, how many users can be supported?
 - (5.2) (1 point) For the remainder of this problem, suppose packet switching is used. To prevent queuing delay, what is the maximum number of users that can transmit at the same time?
 - (5.3) (1 point) Find the probability that two given users are transmitting simultaneously.
 - (5.4) (1 point) Suppose now there are 6 users. Find the fraction of time during which the queue grows.

6. **Written questions (essay, computational)** Consider distributing a file of $F = 15Gbits$ to N peers. The server has an upload rate of $u_s = 30Mbps$, and each peer has a download rate of $d_i = 2Mbps$ and an upload rate of u .

(6.1) (2 points) For $N = 100$ and $u = 700Kbps$, find the minimum distribution time for client-server distribution.

(6.2) (2 points) Suppose the number of peers increases to $N = 1000$, find the minimum distribution time for both client-server and P2P distribution.

7. **Written questions (essay, computational)** Host A and B are communicating over a TCP connection, and Host B has already received from A all bytes up through byte 110. Suppose Host A then sends two segments to Host B back-to-back. The first and second segments contain 100 and 10 bytes of data, respectively. In the first segment, the sequence number is 111, the source port number is 400, and the destination port number is 80. Host B sends an acknowledgment whenever it receives a segment from Host A.
- (7.1) (2 points) In the second segment sent from Host A to B, what are the sequence number, source port number, and destination port number?
- (7.2) (2 points) If the first segment arrives before the second segment, in the acknowledgment of the first arriving segment, what is the acknowledgment number, the source port number, and the destination port number?

8. **Written questions (essay, computational)** Consider the following Figure. Assuming TCP Reno is the protocol experiencing the behavior, answer the following questions. In all cases, you should provide a short discussion justifying your answer.

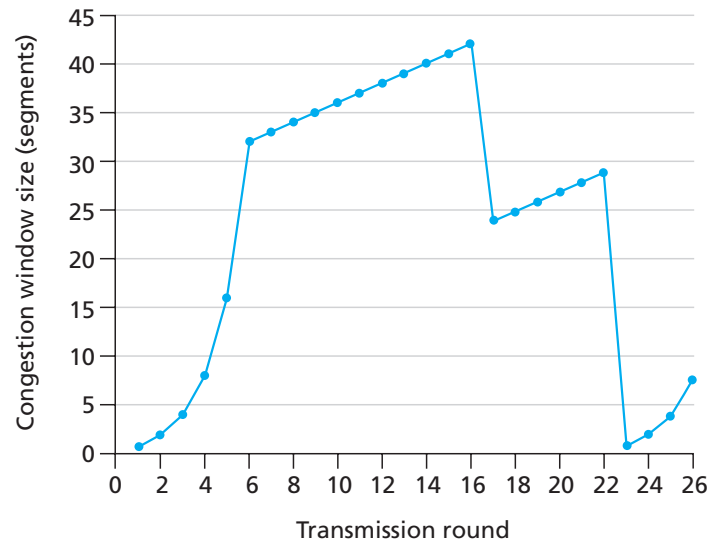


Figure 1: TCP window size as a function of time

- (8.1) (2 points) What is the initial value of `ssthresh`
- (8.2) (2 points) Suppose TCP Tahoe is used (instead of TCP Reno), and assume that triple duplicate ACKs are received at the 14th round. What are the `ssthresh` and the congestion window
- (8.3) (2 points) After the 16th transmission round, is segment loss detected by a triple duplicate ACK or by a timeout?